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Analysis of effect of Polyurethane Bushing on stress distribution of Anti-Roll bar

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Abstract— Anti-roll bars utilized in ground vehicle to reduce body roll by opposing any unequal vertical motion between the pair of wheels suffer from fatigue failure. The objective of this study is structural analysis of an anti-roll bar made of SAE 9262 with different bush wall thickness, were carried out by means of finite element (FE) technique using ansys workbench16 to determine stress distributions in bar. In this study we analyzed the hollow and solid bar. The result obtained by of FEA analyses using ansys workbench16 shows that equivalent stress in the inner surface of the corner bend of anti roll bar was the maximum; where is the chances of failure of bar more .The bush wall thickness (5, 7.5and 10 mm) was consider in this analysis. The roll stiffness of antiroll bar where calculated numerically. It was found that for both bars solid and hollow, thick wall thickness of bush tend to reduce stress in the cornering region. Result shows the Changing thickness of bush for solid bar from 5mm to 7.5 mm approximately 9 % improvement and that 5mm to 10mm approximately 11% .and that for hallow bar 6%.

Keywords— Anti-roll Bar,Ansys workbench16,Bush wall thickness, Fatigue failure, FEA analysis, Roll stiffness, solid and hollow bar

INTRODUCTION

In today's automotive industry the main task that faces the engineer to develop the vehicle which should be dynamically stable. The lot of research is going on in developing the parts which satisfies the above condition. The cost factor also considered during development.

Anti-roll bar also known as stabilizer bar or sway bar was one invention used in stabilizing the vehicle[1]. Anti roll bar utilized in ground vehicles to reduce body roll by opposing any unequal vertical motion between the pairs of wheels suffer from fatigue failure[2,3]. Basically structure of anti-roll bar is U shaped as shown in figure1.[1,4]

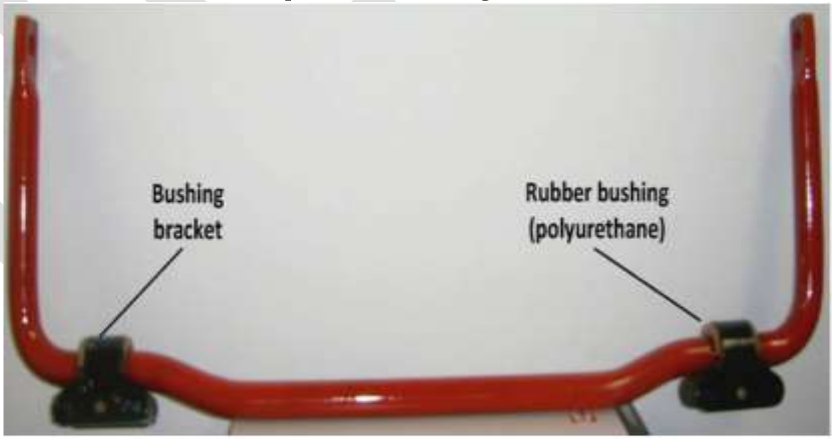

Fig.1-Anti roll bar with bush

The ends of the anti-roll bar are connected to suspension system. Anti- roll bar is made in hollow as well as solid. Now a days different shapes of anti-roll bar is available whose main function is reducing the body roll. Basically roll occurs during cornering due to weight transfer towards outer side [5,7].

Anti –roll bar attached to the chassis by means of bush. There are basically two common types of anti-roll bar bushings [6].They are classified according to (degrees of freedom) the axial movement of the anti-roll bar in the bushing. In both types, the bar is free to rotate within the bushing. In the first bushing type, the bar is also free to move along bushing axis while the axial motion is prevented in the second type.

Fig. 2– Bushing (rubber bushings and metal mounting blocks)

Material of bushing also effect the stress values of anti roll bar[8] .Thus bushing material is also another an influential parameter. Thecommonly used material for bushing are rubber, nylon or polyurethane[9]. Metal bushings are used in some race cars. Enhance in the spring stiffness of bushing material also increases the roll stiffness of anti roll bar [10].
The important function of anti-roll bar is to decrease the vehicle body roll. Vehicle body roll occurs when a vehicle diverge from straight-line motion where it goes. The imaginary line connecting the roll centers of front and rear suspensions forms the roll axis of a vehicle. C.G. of a vehicle body (center of gravity) is basically above this imaginary roll axis[11].

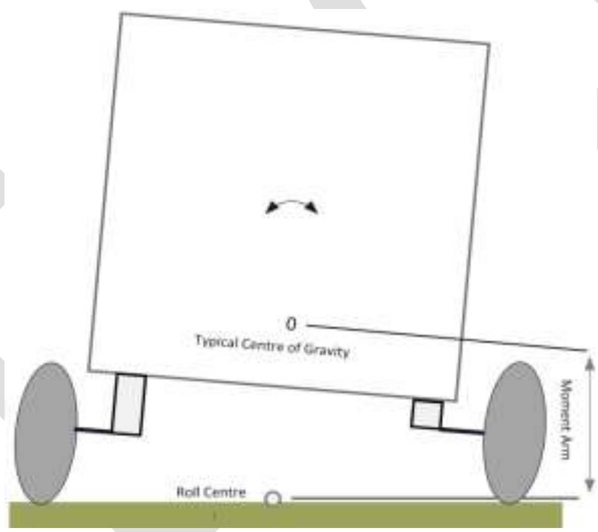

Fig.3-Centre of gravity and Roll axis of vehicle

Thus, while cornering the centrifugal and other cornering (side wind) force cause to produce a roll moment about the imaginary roll axis, which is equal to the product of centrifugal force with the distance between the roll axis and the center of gravity as shown in fig.3. This moment causes the inner suspension to extend and the outer suspension to compress, thus the body roll occurs [12]
In this analysis anti-roll bar made of SAE 9262 steel is used. SAE provides information about anti –roll bar manufacturing technique, equations to find roll stiffness etc.
The main objective of this paper is analyze the effect of different bush wall thickness on stress values of anti roll a bar .Author take here three types of bush wall thickness(5, 7.5,10mm) and analyzed its effect on solid as well as hollow bar. The polyurethane material used for bush

METHODOLOGY

1. CAD Modeling
2. FEA Analysis

3. Numerical Calculations

1. CAD MODELING

All Dimension of anti roll bar is taken from SAE. CAD Model is made in Unigraphics (NX9). The following Fig4.shows the CAD model. The Design is made for Solid and hollow bar.

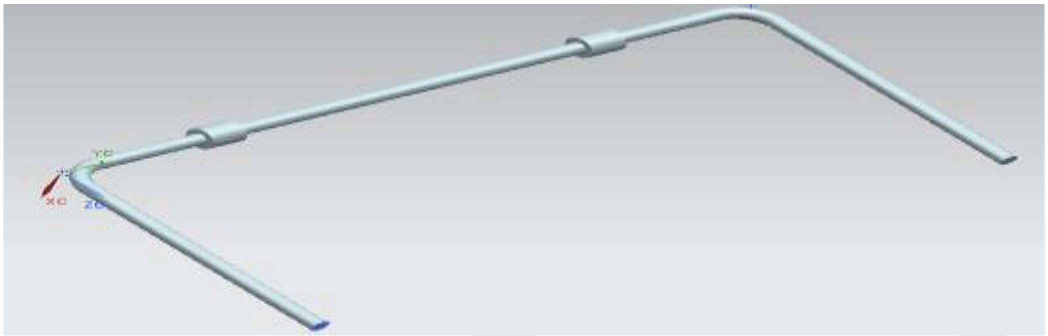

Fig.4- CAD model of anti-roll bar with bushing

According to design model was crated .sweep along curve and revolve command used many times. The model is saved in step file format. Same model was created for different bush wall thickness. Here bush wall thickness of 5mm, 7.5mm and 10 mm were modeled.

2. FEA ANALYSIS

FEA analysis were carried out using ansys workbench 16software. The analysis were carried out for different bush wall thickness. The following procedure were adopted while analysis.

Procedure for analysis

1. Import Step format file into ansys   workbench16.
2. Apply material properties to bush and bar.
3. Mesh the model.
4. Apply boundary condition and force condition.
5. Use Surface to surface contact between bush and bar.
6. Plot Von misses stress and total deformation.

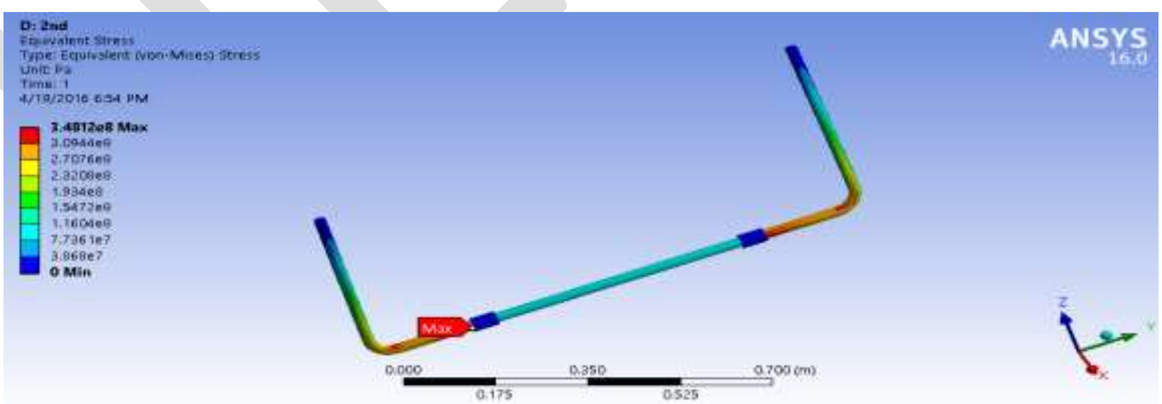

Fig.5- Principle stress for solid anti roll bar with bush wall thickness 5mm

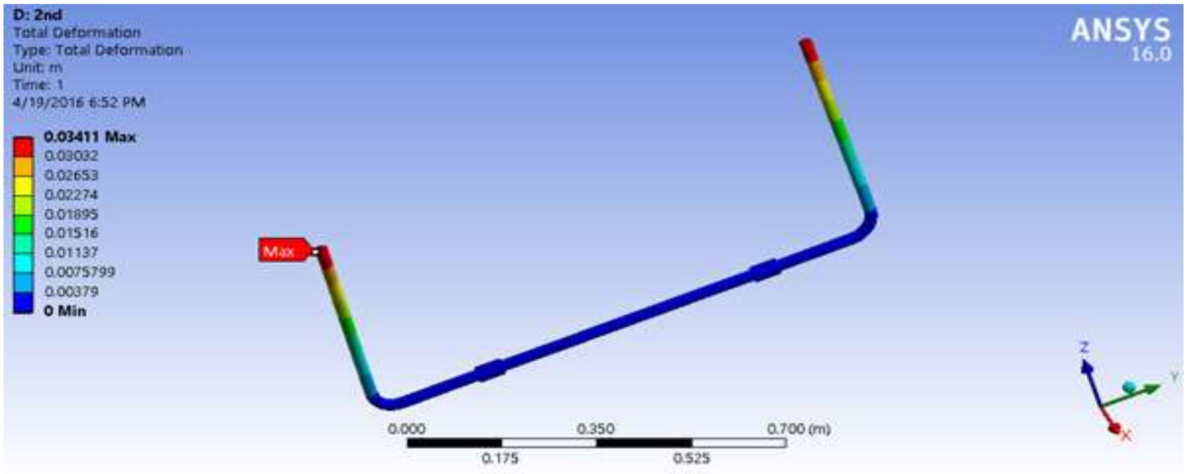

Fig.6- Deflection of solid anti roll bar with bush wall thickness 5mm

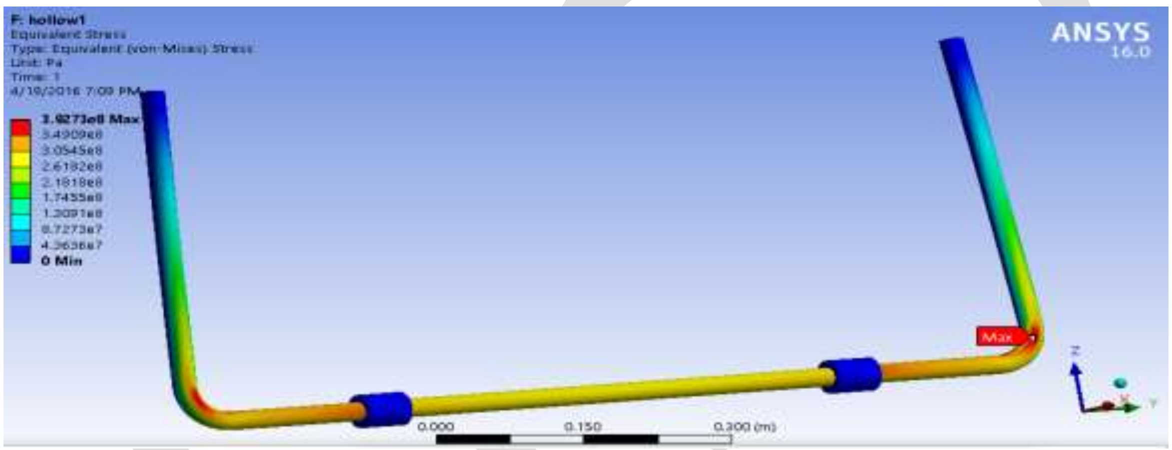

Fig.7- Principle stress for hollow anti roll bar with bush wall thickness 5mm

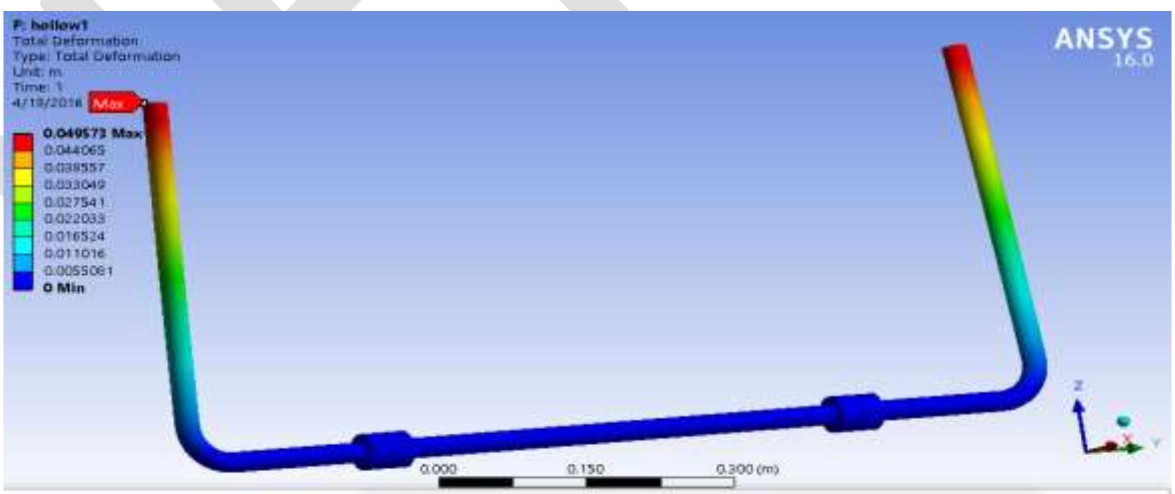

Fig.8-Deflection of hollow anti roll bar with bush wall thickness 5mm

3. NUMERICAL CALCULATION OF ROLL STIFFNESS OF ANTI ROLL BAR

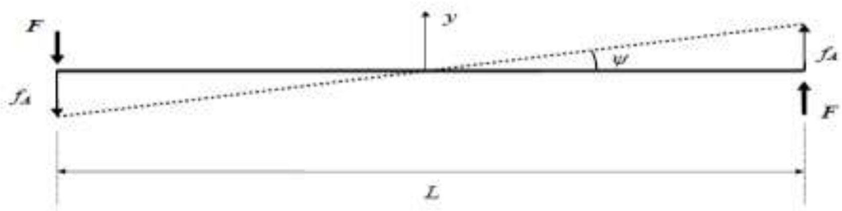

Fig6. FBD of bar

$$k_R = \frac{FL}{f_A} \quad \left(\frac{\text{Nm}}{\text{mm}}\right)$$

Where,
K_R= Roll stifness
F= Force
L= Lenghth of tortion bar
F_a= Displacement

$$k_R = \frac{FL}{\tan^{-1}\left(\frac{f_A}{L/2}\right)} \quad \left(\frac{\text{Nm}}{\text{deg}}\right)$$

$$f_A = \frac{P}{3EI}\left[l_1^3 - a^3 + \frac{L}{2}(a+b)^2 + 4l_2^2(b+c)\right]$$

For solid Bar

$$f_A = \frac{1000[400^3 + 500 * 200^2 + 4 * 400^2 * 500] * 64}{3 * 2 * 10^5 * \pi * [25.5^4 - 17.5^4]}$$

f_A = 33.88mm

$$k_R = \frac{1000 * 1000}{\tan^{-1}\left[\frac{33.88}{500}\right]}$$

k_R= 257.96 Nm/degree

For hollow Bar

$$f_A = \frac{1000[400^3 + 500 * 200^2 + 4 * 400^2 * 500] * 64}{3 * 2 * 10^5 * \pi * [24^4]}$$

f_A = 41.34mm

$$k_R = \frac{1000 * 1000}{\tan^{-1}\left[\frac{41.34}{500}\right]}$$

k_R = 211.574 Nm/degree

Result and Discussion

The main purpose of this study to reduce the principle stress in critical zone(bent of Anti roll bar).So that fatigue life of anti roll bar is increased. To achieve this, analysis of anti roll bar with different wall thickness of bush were carried out. The following table shows the deflection of anti roll bar numerical method and FEA method.

Anti roll Bar	Roll stiffness (Nm/degree)	Deformation (mm) By Numerical method	Deformation (mm) by FEA method
Solid bar	211.09	33.88	34.812
Hollow bar	257.96	41.34	49.57

Table1- Roll stiffness and deformation of solid and hollow bar

Table 2 shows the variation of principle stress value on antiroll bar with changing the wall thickness of bush.

Anti roll Bar	Stress value(MPa) Bush thickness(5mm)	Stress value(MPa) Bush thickness(7.5mm)	Stress value(MPa) Bush thickness(10mm)
Solid bar	348.12	316.80	309.6
Hollow bar	392.73	377.02	369.16

Table2: stress values of solid and hollow bar for different bush thickness

It is clear that the principle stress value depends upon the material property and wall thickness of bush. With increase in bush wall thickness the principle stress value decreases.

Anti roll bar	Mass(Kg)
Solid bar	6.5913
Hollow bar	4.0344

Table3.Mass(kg) of solid and hollow bar

CONCLUSION

Stress distribution of an anti-roll bar has been investigated by using FEA method. Structural analysis shows that the stress values maximum at the corners of the hollow and solid bar that critical for fatigue failure. The position of maximum stress magnitude is at same place irrespective of bush size and bush material. It was concluded that the reduction in stress magnitude obtained by increasing bush wall thickness. Result shows the Changing wall thickness of bush for solid bar from 5mm to 7.5 mm approximately 9 % improvement in principle stress and that changing wall thickness from 5mm to 10mm approximately 11% . and that for hallow bar 6% improvement in principle stress.

Use of hollow bar reduces the weight , from result it is clear that approximately 2kg reduction in mass takes place by using hollow shaft.

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